Development of Track Work

W. O. Lichtner

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for the Degree of

Bachelor of Science in Civil Engineering

Having completed the prescribed course of study in

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DEVELOPMENT OF TRACK WORK.

(INTRODUCTION)

The object of this thesis is to show purely the development of track work, I say purely because to take up the development of track work in the full est and most complete way it would be necessary to write several volumes as it would necessitate the taking up of the use and treatement of wooden ties and their relation to the rail, right of way improve ments, the development of railway coaches, the increase of freight, and many other branches which could be enumerated and finally the interlocking sys tem would have to be discussed which in itself is perhaps a subject even too great to be taken up fully in a thesis. The development as I intend taking it up is to first take up the rail itself and show the forms and uses to which they were used and how they were finally developed to our modern rail and how they are today cut, bent, and put together so that the trains can be switched from track to track almost at will.

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DEVELOPMENT OF TRACKWORK.

Ever since wheel carriages were first used for facilitating transportation from place to place, various devices have been employed to get them there, the least expensive way. The most common method at first, consisted in leveling and hardening the common roads, and the degree of perfection to which they have been carried generally corresponding to the degree of civilization of the country where they were situated.

The transit of coal from the mines required something more than a mere good road and consequently a double parallel line of wooden beams or trails were fixed to the ground and furnished with flanges to prevent the wheels of vehicles from slipping aside. Along these flanged beams wagons were drawn by horses with such comparative ease, that the load which could be drawn by one horse could almost be tripled. These new thoroughfares, which were commonly known as tramways, were laid across fields. The coal districts referred to above were in England and to this district perhaps is indisputably due the contrivance which led to the modern railway with all of its wonderful machinery.

The date of the invention of tramways is uncertain, but by the good authorities occured between 1600 and 1650. From Northern coal districts of England it gradually spread to other parts of England and Scotland. About 1676 the tramways consisted of rails made of scantlings of sound oak and were connected by sills or cross timbers of the same material, pinned to-

gether with oak treenails. Not until 1700 was there any marked advance on the original tramway, the first step being probably the prevention of the wear and tear of the rails. This was accomplished by the use of an additional or wearing rail which could be easily renewed when worn, and was placed above the supporting rail. It became a common practice to nail iron pieces of wrought iron on the surfaces of the ascending inclines of the road and at a time, these strips of iron were placed even on the level track. These bars of rails were about two inches wide and one-half inch thick, and were fastened to the wood rails by countersunk spikes. In sketch I is shown a rail of this kind, but which of a later date is somewhat improved in that it is provided with wooden stringers. The ties were notched, thus avoiding all side movements of the rails. These wooden stringers and strap rails were used in 1837 on the Albany and Schenectady R.R.

Side View.

End View.

Sketch I.

Cast iron was first incidentaly used or tried as a material for rails about 1740. The earliest iron used in track construction was cast in plates 2' to 4' long, 2" to 3" wide, and 1/2" to 3/4" thick and were drilled with three holes through

which they were fastened to the oak rails or these plates were spiked on top of the wooden stringer rail where the wear was the greatest. The tramway was developed into the railway by the employment of cast iron flange rails to replace the wooden rails; the continuous flange or ledge on their inner edge kept the wheels on the track. These species of railways became pretty general in mining districts but did not impress the people as being suitable for general traffic.

The use, however, of cast iron rails led to an improved method of traction in that it led to the plan of linking together a series of smaller wagons instead of using a single large wagon. The next improvement consisted in putting flanges on the wheels instead of the rails, by which great facility of transit was afforded. The draught still continued to be executed by horses for some time but with the invention of locomotives and heavier rolling stock new designs of rails were invented to suit conditions.

The price of iron played also a great factor in its being used for rails and as the price was materially reduced as coal became cheap and abundant, it at length became possible to use it in the construction of rails. As timber was dear at the close of the last century in England many attempts were made to devise a cast iron rail that should suit the traffic of the English tramroads. Sketch II shows one of the first cast iron rails which was laid on a road in Loughborough in 1789. The rail was fish-bellied and at first was not supported by a chair, the wood or stone blocks being hewn to fit the end of the rail. Near the ends the rail had a flat projecting base in which there

were holes for the bolts which fastened them to the wooden block or sleeper.

Sketch II.

Sketch III shows a so called cast edge rail with joint supported by chairs. This rail was used about 1790. These were the first chairs that were ever adopted. They were cast the reverse of the rail, having two bolts through the stem or web of the rail at each joint. They were laid on the Lawson Main Colliery Road, New Castle on Tyne, England, and were at first supported by timber but finally by stone blocks.

Sketch III.

In 1802 Mr. Wyatt invented what was known as Wyatt's Hexagonal Rail which is shown in sketch IV. This rail was used on the railway at the slate quarry at Lord Penhyn's estate, near Bangor, North Wales. The general shape of the cross-section of this rail was a hexagon. At each end of the rail a dove tail block 2" long was cast at the bottom. This was slipped into a chair, which had previously been attached by a bolt to the wooden or stone support.

Sketch IV.

Another design of a cast iron rail was used by the Surrey Ry. in 1803 which was called the Tram rail, shown in sketch V. As can be seen the flange is higher in the middle and had a rib under the tread to add strength. These rails had a rectangular notch, a half square, in the ends. The joints being completed by one square headed iron spike, which was counter sunk.

Sketch V.

The fastening or joining together of the seperate rails was very unsatisfactory and this led to several inventions of different kinds. In 1806 Charles Le Tall of Llanelly, Wales received a premium of 20 guineas from the society of Arts for the invention of the rail shown in sketch VI. The rail was very ingenious in construction and was designed to be used without bolts or spikes. Projecting lugs pyramidal in shape were cast on the bottom of the tram rail at the points where the stone supports came under the rail, the joints being dovetailed into each other. These rails were 5" wide and weighed 42# per yard.

Sketch VI.

Another design which was invented in 1815 was known as the Losh and George Stephenson rail. It consisted of a half lap joint through which a horizontal pin was passed transversely and joined the rails together, at the same time fastening them to the cast iron chair.

Again retracing a part of our steps we find that in 1784 the idea of having a rail rolled seems to have been thought of and consequently Lord Carlisle's wrought iron rail was invented. We see from sketch VII that this rail consisted of bars of wrought iron rolled in 12' lengths laid correctly flat on oak stringers. The development of these kind of rails was going on the same time as the cast iron ones, although the wrought iron rails were winning favor while the cast iron was losing same.

Sketch VII.

In 1820 John Birkenshaw invented a wrought iron rail as shown in sketch VIII. A clause in the patent specifications reads "The upper surface to be slightly convex to reduce friction. The upper part to rest on supporting blocks, chairs, and sleepers. The wedge form is used because the strength is proportional to the square of the base times the depth. Hence this wedge form of rail possesses all the strength of a cube equal to its square. The joints are made with a pin. Birkenshaw showed great ingenuity in designing the rolls by which these rails were fairly rolled in 18' lengths.

In 1828 the rail used by Stephenson was rolled in 15 ft. lengths supported every 3 ft. and weighed 35 lb. per yd. This rail resembles the cast iron rail shown in sketch VIII except that Stephenson's rail did not have the lap joint. A cross-section of the original rail laid on the old Portage R. R. over the Alleghanies in 1832 is shown in Sketch IX.

Sketch VIII.

These rails were imported from England in 1832. The track development so far had only been done in foreign countries. Not till after the year 1828 or so was anything attempted in America. The British Ry. projectors had the advantage of being able to call into their service a trained force of civil engineers. Many of these engineers were connected with well organized scientific societies or were generally experienced in the construction of public works, and were familiar with what had been done for years. On the tram roads. Men on whose judgement the wealthy capitalist were willing to supply the money for the proposed improvements. With the exception of making the railheavier and using steel instead of iron and substituting an iron for the wooden cross tie. and strengthening the splice chair there had been no great change in the English system of track laying in the last fifty years.

Many of the civil engineers who were called in the service of the American R.R. were connected with the army engineer corps, having obtained the training at West Point the only institution in the U.S. where engineering was taught during the first quarter of the century. In many cases these officers were detailed for a number of years to the Board of Engineers for Internal Improvements.

Railroads at that time were built having curves and gradients which were frequently sharp and steep as few cuts or fills were made, and these cheap roads were quickly extended through a rapidly growing country, with a view to connect the navigable courses. There being no rail rolling mills in America at this time the rails used were of the timber type called with strap iron. Some of the roads however such as the Camden and Amboy in N.J. and Boston which did not adopt this construction were compelled to obtain their edge rails and fastenings from England.

The directors of the Camden and Amboy R.R. sent their chief engineer Stephens to England to inspect and report on railroad matters. He was familiar with the Birkenshaw rail but saw that as it required an expensive chair to hold it in place it was not adapted to our country where metal workers are scarce and iron was dear. He added therefore the base to the T rail, dispensing with the chair. He also designed the hook headed spike which is substancially the railroad spike of today. The base of the rail which he first proposed was to be wider where it was to be attached to the supports than in the intervening spaces. This was afterwards modified so that the base was made the width, 8" throughout. He succeeded in interesting a member of parliament and proprietor of a large iron works in Dowlais, Wales. After having the

rolls made he succeeded after [illegible] time to roll the rails. The first shipment consisted of [illegible] bars, 18 ft. [illegible] per yard which arrived [illegible]. [illegible] of the next shipment [illegible] to 42# per yd., the rail being [illegible] high. This rail was fastened to stone blocks with hook headed spikes. A sketch of this rail is shown in sketch X. Sketch XI shows the standard track for this road.

Sketch X.

[illegible]

It is interesting to note the vast difference of the way the Americans and English have [illegible] after having started to roll rails. The first rail mill erected in this country was located on Mount [illegible], [illegible] Co., Maryland. The first rail was rolled in 1844. The rail was of [illegible] to the Evans patent and first few hundred tons manufactured were laid on the [illegible]. A section of this [illegible] 42# per yd., is [illegible] sketch XII.

Sketch XII.

Sketch XIII shows the Stevens rail as used on the Philadelphia and Reading R.R. in 1837. The rail was supported by chairs. This method was believed at the time [illegible] considerable in advance upon previous practice, but was soon abandoned on account of the increase in expense which it entailed. The Stevens rail was laid on the Vicksburg and Jackson R.R. in 1840. In the southern states the longitudinal planks, which were placed under the end of the cross ties on many of the Railroads were called "[illegible]" and this [illegible] historic during the Civil War, 1861 - 1865. See Sketch XIV.

Sketch XIII.

Sketch XIV.

The Stevens rail had come into general use in America before 1845 although several Railway Companies which had imported T rails from England continued their use on [illegible] until the rails were worn out. Every American road without exception replaced the T rail and strap rail by the rail of the Stevens pattern, as rapidly as their financial condition permitted, continuing to import all rails from England until 1845. The T rail shown in sketch XV is the style used on the Boston & Worcester R.R. in 1850.

Sketch XV.

[illegible] the year [illegible] a [illegible] experiment was tried by the [illegible] [illegible] a [illegible] [illegible] between [illegible] and [illegible] [illegible] [illegible]. The [illegible] best solved the problem [illegible] [illegible] [illegible] [illegible] [illegible] a [illegible]. [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] by Architects [illegible] [illegible] [illegible] [illegible] [illegible] [illegible].

The [illegible] [illegible] [illegible] with [illegible] [illegible] the next fifteen [illegible] years. [illegible] [illegible] sketch XVI.

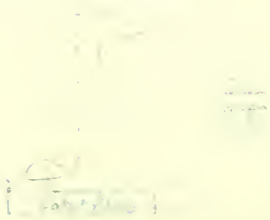
[illegible] XVI.

The [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible]

[illegible] Sketch [illegible]. [illegible] of [illegible] fixtures [illegible] the [illegible] rail [illegible] [illegible]

[illegible] rails [illegible] engineers [illegible] of this [illegible] in sketch [illegible] fixtures [illegible] compound [illegible] The Z iron [illegible] of longitudinal [illegible] sills, [illegible] cross ties, 3-1/2" x [illegible]" and 7' long. [illegible] against the [illegible] Z iron [illegible] iron wood [illegible] except a [illegible] at the joints.

Sketch [illegible]



Sketch [illegible]

A section of an [illegible] rail laid on the [illegible] is shown in Sketch II. [illegible] sections are shown below also.

Sketch II.

[illegible] compound rails [illegible], it is [illegible] who made [illegible] first [illegible]. [illegible] that time and as the [illegible] rivets [illegible] became heavier, the different parts of the rails [illegible] kept together [illegible] attention, [illegible] putting in new rivets. As the rails [illegible] of [illegible] the wear of the [illegible] the [illegible] solid rail was substituted.

The next [illegible] of rail to be considered is the [illegible] rail. The [illegible] rail [illegible] 4-1/[illegible]" [illegible], the [illegible] 4" and web 1/[illegible]" thick; the angle of inclination [illegible] 4. Sketch III shows a section of the [illegible] rail. Substantially this [illegible] United States previous to 187[illegible]. Mr. [illegible] in this direction [illegible] rail designers in [illegible]. In [illegible] attached [illegible] report of his in 1874, in which [illegible] pattern [illegible], he states

"I [illegible] decided mistake [illegible] the [illegible] of the [illegible] shape enough, [illegible] too much to [illegible] head."

Sketch [illegible].

The introduction of [illegible] conflicts in the U.S. patent of [illegible] form [illegible] [illegible].

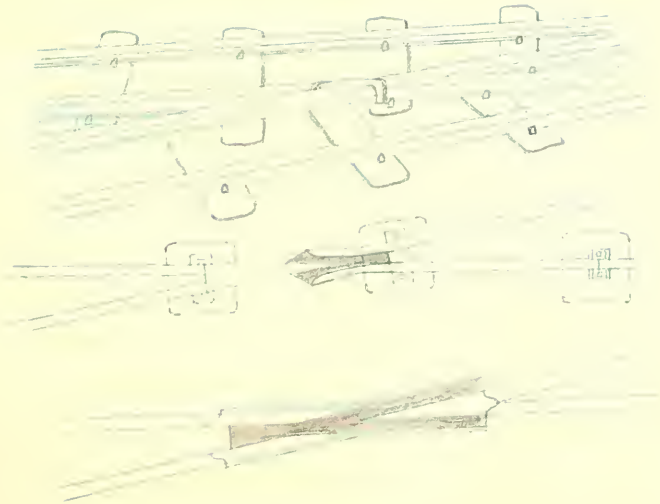
In Crank's "History of [illegible] made [illegible] rolled at the North [illegible] mills [illegible]. The first st[illegible] rolled by [illegible] in [illegible].

[illegible] the standard sect[illegible] [illegible] roads are shown in SketchXXII.

Sketch [illegible].

The foregoing has shown to the reader the changes which have taken place with respect to the [illegible] size, shape or strength of the rail, and from now on, a new proposition will be taken up, that is, to show how the rail is shaped and joined together so as to be able to run the engine in and out of a structure where they can lay over between runs and also cross over from one track to another. In other words, will show the developement of frogs, switches, crossings, etc., which became necessary due to the conditions cited above.

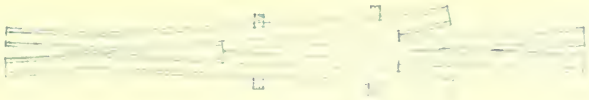
When it became necessary to run the engines in or out of the round house, the [illegible] was straddled across the rail, the two arms of the [illegible] dropping into holes bored into the sleeper or tie. The iron of which the [illegible] was made was thick enough to raise the flange of the locomotive wheel above the top of the rail. After the engines had passed the [illegible] was taken out. A sketch of this shown below.



Frogs of various shapes were used on the colliery lines of England previous to the introduction of the locomotive, these as will be seen from sketches on previous pages were in most cases at the theoretical intersection a piece of cast iron so shaped as to allow the flange of the wheel to pass through. The safety of this kind of frog depend upon the amount of wear as well as upon the strength of the cast iron. As the speed of the trains increased the cast iron frog proved to be unsafe and various forms of rail frogs were constructed.

Frogs are of two kinds; first, rigid or stiff rail frogs and second, spring rail frogs. In the first kind all of the parts composing it are supposed to be rigidly connected. The parts of both the rigid and spring rail frogs are joined together in three different ways: first, by placing filler blocks between the pieces of rails and bolting them together with bolts passing through the webs; second, by riveting the pieces of the rails together; and third, by clamps or by clamps and wedges.

Taking up the rigid clamp frogs first, the frog may be held together in two ways; first, by wedges which are driven against the web of the rail and held in by keeps, or else by wedges which are held by counter bolts which draw them to a close fit; and second, by solid clamps which embrace the frog rail pieces directly by a close fit around the rail flange and against the web, the clamps being held in place by cotter bolts or side rods that pass through the clamps and are fast to the wing rails. One well known example of this type is shown in



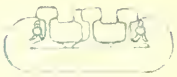


Plate XXIII. The side of stay [illegible] around the ends of the [illegible] walls. As the [illegible] slipping back by [illegible] them on the roof.

Another [illegible] is type [illegible] two steel plates 4" wide by 1-1/8" thick [illegible] fastened on each of two steel [illegible]. The [illegible] by a long through rib. The [illegible] satisfactory service [illegible]. The [illegible] loose in spite of the [illegible] to keep the [illegible] tight. [illegible] the [illegible] turn out to [illegible] the [illegible] must be notched to let the [illegible] out.

The riveted [illegible] type which was used quite extensively [illegible] degree. [illegible] plate by two [illegible] counterset on the under side. This plate [illegible] at least 8ft. long [illegible] just [illegible] riveting, so as to [illegible] the [illegible] loose, so that the [illegible] style of plate riveted from the [illegible] a combination style [illegible] together and then riveted to the base plate. This style of [illegible]

is shown in Sketch [illegible].

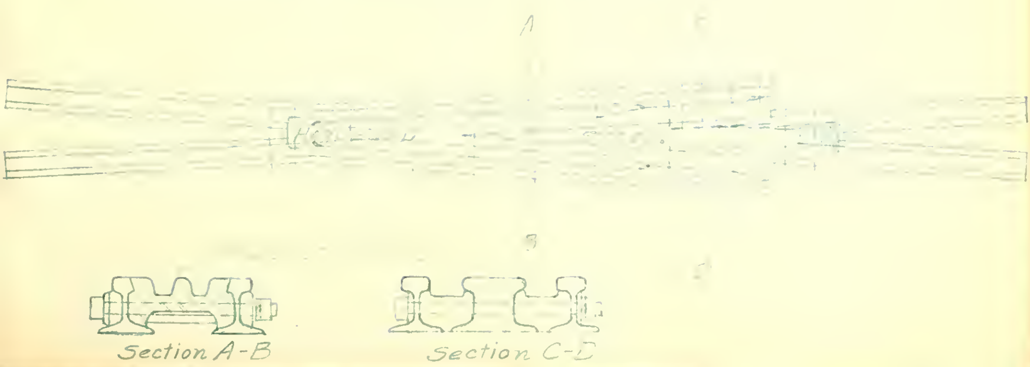
This leads u[illegible] the [illegible] bolted frogs [illegible] the best satisfaction of the three common types [illegible] frogs. As the name indicates the rails are [illegible] to [illegible] bolts, which hold the wing rails and point rails rigidly in position. Sketch XXIV, shown above to illustrate the combination bolted and riveted frog would be a simple bolted frog [illegible] of the bottom plate to the frog. As the life and usefulness of a bolted frog [illegible] tightened many devices such as [illegible], cotters, [illegible] to prevent the bolts from loosening [illegible] the frog.

[illegible] the W. Wharton Jr. & Co., Pennsylvania Steel Co., [illegible] hardened steel [illegible]. Notwithstanding [illegible] times [illegible] steel rail frog [illegible] question, the most economical frog to use.

Lece thy [illegible] greatly to the value in ultimate economy of their hard center frogs [illegible] by patented process, to restore [illegible] frogs to a [illegible]

tically [illegible] [illegible] [illegible] [illegible] [illegible]. [illegible] [illegible] [illegible] [illegible] relevelling [illegible] surface [illegible] [illegible] [illegible] points by [illegible] [illegible] grinding. [illegible] [illegible] [illegible] [illegible] rails. [illegible] hardened steel frog, [illegible] experience [illegible] [illegible] ordinary frogs, [illegible] [illegible] entire [illegible] life at a good [illegible].

It will be noted from the sketches below that the hardened steel part is a complete frog in itself, the point as well as the wings being of hardened steel in one solid casting, simply bound in by the rails. As all the strains are received and resisted by the central casting itself, the bolts [illegible] [illegible] do not as a rule get loose and therefore require no tightening. This has been especially noted, the frogs needing very little or no attention while in service. In many cases the hardened steel [illegible] frogs have replaced [illegible] frogs on main lines, the slow wear insuring long continued smooth riding, [illegible] [illegible] therewith greater safety. Where the traffic is severe on one line of the frog only, a one sided hardened steel frogs in which only one of the wings is of hardened steel, while the other is formed by the ordinary rail. The cost is approximately twenty-five per cent less than the [illegible] [illegible] frogs.



Sketch 25 shows one of the oldest types of switching frogs invented of which Mr. Joseph Wood of Redland, N.J., was the inventor. This formed the basis of the invention of many types of spring rail frogs now in use.

Sketch [illegible]

Probably the oldest pattern of the spring rail frog was known as the "double spring rail frog". This frog consisted of a point rail and two long rails on each side of the point rail. These long spring rails were left to lie loose to the point rail and were only fastened at the ends so that as the flange of the wheel trailed through, the spring in the long rail sprung the rail back into position. A sketch of this frog as well as the so called single spring rail frog are shown in sketch XXVI. The single spring rail frog was a modification of the double spring rail frog except that this frog has only the one spring rail and the point rail and the one spring rail were permanently attached to a plate. This same idea is the basis on which our present spring rails are built. The one serious defect in these frogs was the excessive wear on the spring rails due to the flange of the wheel trailing through the frog and forcing the spring rail to one side. The single spring rail frog was not as objectionable in that it left the rail line open so that if the siding was only used a little the objections would not be so great to this type of frog.

[illegible]

Another serious feature of the type of frog discussed above was that there was no way in which to fasten the spring rail except at the ends thereby entailing the great danger of the rail from turning over. The remedy of this was to make the main out-side rail hinged which was held normally against the frog point by a spring. As to the position of the spring which holds the movable rail in position there are diverse arrangements. The main object in placing the spring is to so operate it that a derailed wheel cannot break or bend it so as to put it out of service. One arrangement which is considered the safest against derailed wheels is that of using a boxed spring which acts against the movable rail somewhere between the point of frog and the heel, with no bolts through the frog. This arrangement is found most frequently, but not exclusively, with hinged rail spring frogs.

The spring rail frog is far more durable than the rigid frog, as it presents a continuous leaving main-track rail, and does not therefore allow the wheel to drop in the throat or channel after trailing the point and cut into the main rail at the outer edge of the tread. Its life is generally considered to be at least three times that of a rigid frog. Spring-rail frogs of various designs have to a large extent taken the place of

rigid frogs for main line service are [illegible] standard. For the successful operation of [illegible] three devices are recognized as particularly essential: namely, an anti-creeper device, a holding-down device, and a reinforcement for the spring rail.

The degree of creeping in frogs is quite large, thus for instance, creeping might cause the holding down arms to bind so hard in the housings that the springs would not be able to bring the movable rail back against the point rail after being opened by passing wheels. There is also a danger element in unrestrained creeping in that the bolting action of the spring rail may be so intense that it will not spread for the wheel of empty freight cars, for instance, trailing out of the movement. In such cases cars have been known to climb the rail at the flare and go off of the track. An anti-creeper arrangement that is used very often is a cast iron anchor block bolted in between and [illegible] the two joints at the toe and spiked to the tie underneath.

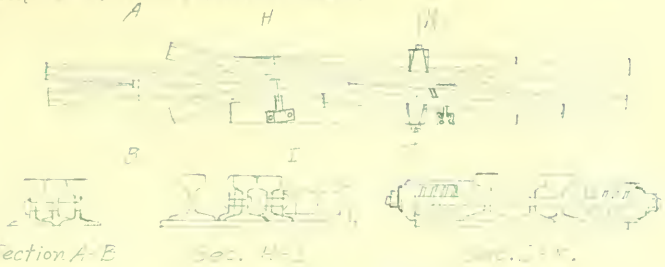
In order to hold down the free end of the spring rail while wheels are passing a low joint at the toe or prevent it from being raised by dirt or snow, or from being torn up by a dragging brake rear, several devices are in use. One method consists of a flat bar bolted to a base plate and passing through a slot in the web of the spring rail, beyond which it is attached to a bolt or shouldered and drawn out into a bolt which passes through the rigid rails. Another device consists of a bar or plunger bolted to the web of the spring rail, and [illegible] into a holding down cuff or guide box secured to the base plate.

This cuff permits some longitudinal play of the spring rail but no appreciable vertical play.

The spring rail does not usually rest against the torque but is flared out over a length of about 8", so as to allow the wheel flange to pass the point when entering the turnout without crowding the spring rail over. This arrangement is calculated to relieve the guard rail opposite the frog of some strain. The loose end of the spring rail should be flared out gradually so as to avoid sharp blows when it is run over by trailling wheels and prevent sharp wheel flanges from cutting into or mounting it. The usual flare, measured when the spring rail is closed against the point rail, is 3-1/2 to 4 inches, and the length of the flare, 17 to 20 inches. To illiminate the cutting action of worn wheel treads it is necessary to channel or groove the head of the spring rail parallel to the track gauge line, and to such width as will cover the reach of the outer flange of any badly worn tread.

To avoid the necessity for special devices to prevent disturbance to the spring rail by creeping of the track and to render the spring rail less dangerous in case of breakage, several designs of frogs have been brought out wherein a short spring rail is hinged either to rigid leg or to the base plate opposite to the mouth, or to the main point rail at the heel, thus removing it from the line of stress. In the "Eureka Frog" see sketch XXVII, the spring rail makes a miter joint with a fixed leg in the throat and is bolted to a piece of reinforcement rail which breaks this joint and is hinged at I - J, thus

affording a double running rail.



Sketch XXVII.

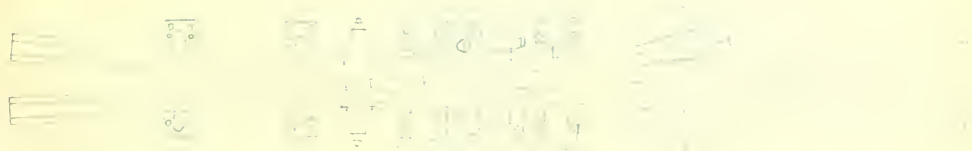
In the Weir Frog of this type, see sketch XXVIII, the spring rail is outside of the gauge line of the main running rail and is bent so as to project somewhat within the opening between the point rail and a rigid piece in the main running rail. It is hinged at A, and is held up to the point piece by a spring E, acting reversely to usual direction on the shorter arm of a pivoted lever, which effects a reduction in the compression of the spring.

Sketch XXVIII.

The Vaughan Frog, shown in sketch XXIX, is quite similar to that just described. The spring rail is hinged at the heel, however, instead of at the mouth and is not bent so sharply opposite the point of tongue. The filling block is arranged to carry the wheels in case of accident to the spring rail and has a rib fitting under the head of the spring rail.

Sketch XXIX.

A good deal of attention has been devoted to frogs of special design for yards, or for the junction of two tracks both of which carry heavy traffic, the object in view being a continuous bearing rail for trains moving over the frog on either track. To accomplish this there is a design known as the Vauclain Gliding Spring Rail Frog, sketch XXX, in which the two movable wings, instead of being rigidly attached to each other, are spring connected in the usual manner. These spring rails are separated by a spacing block on the spring bolt a sufficient distance to maintain an open flange-way in the track in use, the flangeway in the unused side remaining closed. In case wheels passing over the frog in the facing direction run through the closed flangeway, the closed wing is forced open, compressing the spring as in the ordinary action of spring rail frogs, the movement of the other wing rail follows as soon as it is released from the load and the frog then remains set for that route.

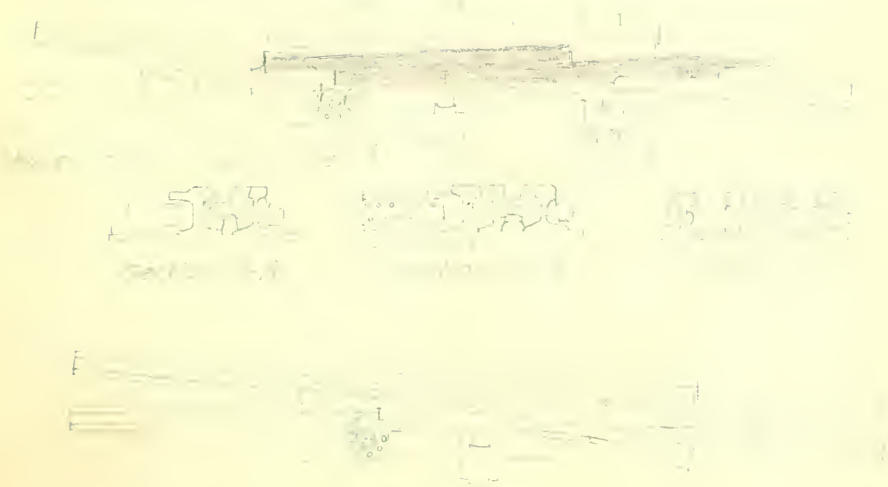


Sketch XXX.

The double spring rail frogs which open and close at every passage of a wheel on truck, see sketch XXXI, are used very little.

Sketch XXXI.

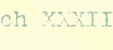
The type of frog which is of substantial construction, with heavy linked anti-creeping attachements on both wings and where either wing acts independently of the other is either expensive for general yard service and the propiety of placing at the end of double track, or at the junction of two main tracks, where high speed is made, any frog with movable parts to be automatically set by the train is certainly questionable. As a matter of fact spring rail frogs of any discription are used but little in yards. There can be no doubt as to the advisability of using them on the main line and as in the case of rigid frogs it has been found to [illegible] cases under heavy trafic to use a spring frog with hardened steel parts to take the beginning where the ware is sually the most rapid. Sketch XXXII shows several designs of these hardened steel [illegible] which are constructed inthe usual manner, the space for the hardened portion being provided for by bending the rail around it.



Sketch XXXII.

Thus far the developement of both [illegible] spring rail frogs have been shown and will now proceed to discuss other forms of track construction.

Two types of switches in use in England in 1855 are shown in sketch XXXII.b. The point rail was placed off to a point as the name indicates and was also hinged on a pin so that the point could be pushed over to the main rail thus permitting the train to turn in the siding. To accomplish this a note on the other side was constructed, as shown below.



Sketch XXXII.b.

On account of the slow speed of the trains, it was not necessary at first to have a movable point rail on both sides of the track, but with the increase in speed of trains it became imperative to use a movable point on both sides of the track, this was the crude form of the present so called split-switch. Among the early forms of switches used in America was the lever switch, with a heavy iron counterweight to keep it in position, commonly known know as the stub switch.

In the stub switch the two rails of each track are cut squarely off at the toe and the switch rails are thrown so as to meet the fixed ends of the lead rails of either tracksquarely end to end. This form was formerly used more than any other one and used even now to some extent, especially in light rail work. It is durable, serviceable, and there is nothing in its make up as particularly delicate. The stub switch is still considerably

used in main track on mountain roads, the generally accepted explanation for the practice being that the heavy snow fall of such regions obstructs the operation of point switches more frequently than the switches can be looked out properly. This has been a point on which engineers of railroads have had many disputes and is still an unsettled question whether or not the average number of delays in trains per year would be less with split than with stub switches or vice versa. Some other objectionable features of the stub switch have made it so that they are not used for main line service at all on the heavy traffic roads. Sketch XXXIII gives a good idea of the stub switch.

Sketch XXXIII.

Although the so called point switch was in use at an early day, still the preference for the stub switch was for many years so strong that it was in some cases equipped with a derailing device to prevent the wheels from leaving the track when trailing the switch wrongly set. One arrangement of this kind was the Tyler Switch, used to some extent at one time. It consisted of a short guard rail bolted to the gauge side of each moving rail and flared to cover the end of the stub rail with an incline plain bolted to the out side of the rail. With this arrangement wheels trailing the switch wrongly set would be caught on one side of the track by the guard rail and on the other side by the inclined plain and guided to place on the

moving rails.

Among some of the objectionable features or points of weakness in the stub switches are the frequent settlement of the headblock, due to the heavy pounding of the wheels at the open space which must be left at the end; and the "tight switch", due to the expansion and creeping of rails in hot weather. Quoting from a Committee report to the New England Road Masters Association in 1890, "The stub switch, with its open joint in winter and tight joint in summer, with a loose headblock to be tamped every few days", is well to the point. The derailment of trains which trail and open or misplaced stub switch is, however, the dangerous [illegible] therefore the most objectionable feature.

The switch rails are connected by tie rods, soap to act together. The throw or the movement of the free ends is usually 4 or 5 inches. They are usually 30' long, and spiked to the ties for a certain distance beyond the heel, this distance being about 5' for a seven and a half degree curve and 12' for a fifteen degree turn out curve.

As has been stated before the split switch was known at a very early date but owing to stub switches and other crude devices to serve the same purpose, and also on account of the higher cost it took a time before they were universally used. The split switches were unlike the stub switches, although they were used for the same purpose, in that the split switches consisted of a pair of movable rails planed to wedged points and set to work against to fixed rails. The movable points are connected by switch rods or tie rods, so that the movement of the points

is always together. The form of split switch now in general service is patterned after the Clarke-Jeffries design, [illegible] worked out by Mr. Leverett H. Clarke, while Chief Engineer of the Illinois Central R.R. and Mr. F. T. Jeffries then an employee of the same road. The distinctive features of this switch are first, that the face of the point rail is planned in such a manner so as to seat it on the flange of the stock rail or guard rail, and second, the crowning of the point rail above the top of the stock rail at the point where the tread or tire of the wheel just reaches the guard side of the latter.

At the end of the point rail is it necessary to plane the head entirely away down to the web and in order to do this and have the guard side of the point rail straight the rail must be left inward at the point where the planing [illegible] begins. From this point the guard side of the point rail head is then planed straight away [illegible] the web at the point end. To avoid heavy pressure from the wheel on the thin portion of the point rail the top of the head is planed down on a slope to within the end 1/4" or so lower than the top of the stock rail. This sloping of the top of the point rail is carried back 15 to 18 inches from the end in view of the fact that the point rail should not extend as high as the stock rail until a point is reached where it is strong enough to bear the whole load. It is also customary to plane out the inside face of the point rail along the top edge, as shown in sketch XXXIV, leaving a shoulder on the web to be housed under the head of the stock rail. This arrangement permits the full thickness of the web to be carried

tp the end of the point rail, thereby making possible much stronger construction than would otherwise be the case.

Sketch XXXIV.

In England a new method of making split switches is being tried, the points being rolled to a taper out of ordinary rail, instead of planing the rail down. The idea in avoiding the use of the planing machine is to preserve the skin or original rolled surface of the rail intact which is supposed to be tougher and therefore better able to stand wear than the planed surface of point rails made in the usual way. Some of these rolled point switches are in use on the Midland Ry.

In connection with switches one of the most important things to take into consideration are the slide plates. On each tie, at least as far back as the point where the bases of the point and stock rails separate, the point and stock rails rest upon iron or steel plates, known as slide plates. These slide plates should extend under both point and stock rails, on the one side, and under both point rail and thread rail on the other side. A short slide plate passing under the point rail only and abutting against the flange of the stock rail is not satisfactory under heavy traffic. They should be at least 5" wide for if they are made narrow they frequently settle into the timber when the ties become old and in such cases one end of the plate usually dips and leaves the point and stock rails unevenly supported. As the point rail rests upon the flange of the stock rail the plates are stepped or thickened by a riser

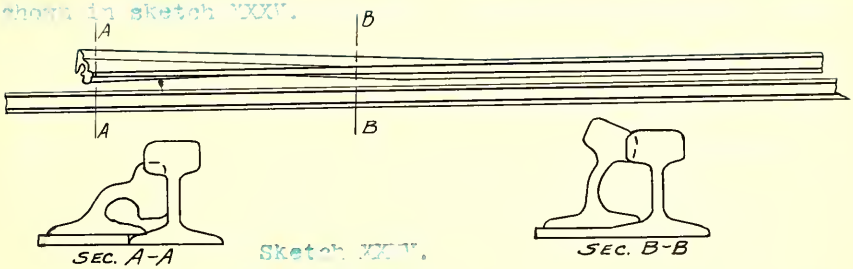
to make a proper bearing for each rail and hold the rails at the desired relative height.

If the throw of the switch is less than 4" guard rails should be placed in advance of the points. These guard rails serve to keep the flanges of loose or improperly gauged wheels away from the open point when they approach from the facing direction and also to protect the points from damage by dragging brake beams. The ends of such guard rails should be placed as near the ends of the point rails as safe clearance will permit, taking into consideration the extent of the rail creeping and the flangeway in this case need not be as narrow as with guard rails opposite frogs. Except under extraordinary conditions short guard rails less than 15 ft. should never be used.

To prevent cars from "splitting" or "straddling" the switch the socalled Vaughan point switch was designed which consisted of long and short point rails. The points are 18 ft. long of ordinary construction except that the planing of the head of the main point rail is run out bluntly [illegible] in rear of the point end; the web and base of this point rail, however, are carried the full length, or to a point opposite the end of the mating switch rail. It is thus clear that after a wheel has taken either side of the longpoint the wheel on the opposite end of the same axle must necessarily take the same side of the short point; it is impossible for a pair of wheels to take both sides of the points. In other words, if a wheel takes the flangeway side of the long point it is impossible for the mating wheel to take the flangeway side of the short point. With the points in any position the wheels cannot get off the

rails. Should the short point by misadjustment or carelessness in throwing the switch remain slightly open, the wheel flanges cannot get behind it, as the flange of the mating wheel, behind the long point, will crowd it over and complete the throw of the switch.

Switch rails as we generally think of them are rails which are tapered by cutting away the head and flange. This of course is a point of weakness and to overcome this objection the Stewart patent switch was invented. The object of the patent switch is to prevent such cutting away and weakening of the switch rails and this attained by means of twisted switch rails as shown in sketch XXXV.



Sketch XXXV.

The switch rails are constructed of lengths of main line rails, twisted in the web so that at the point end the outside edge of the head will be on top, the web being bent at right angles, while the degree of twist diminishes towards the heel where the rails is of usual or normal section. At the point, section A-A the switch rail is raised by means of a plate of sufficient thickness to allow the flange of the main rail and also to allow the head of the switch rail to rest against the web of the main rail and by planing away a very small portion of the head of the switch rail it is allowed to fit in closely to the head of the main rail. The switch rail slopes

upward from the point and the flange overlap [illegible] of the main rail more and more until at 6'-8' the switch rail has reached a normal position with its flange close to the web of the main rail.

In the construction of the switch the only material planed off is that portion of the head of the switch rail shown by the dotted lines and this is planed in such a manner that the head of the switch rail fits closely to the head of the main rail. At 3 ft. from the point the flange of the switch rail gradually rises and is made to conform with its position on the flange of the main rail, the metal being planed off.

Another type of switch, known as the Claxton Switch, was designed to overcome the switch point difficulty by having an unbroken main line track. When the switch is set for the siding the wheels are carried over the head of the stock rail by means of incline rails. Sketch XXXVI shows an outline sketch

Sketch XXXVI.

of this switch. When the switch is set for the siding, the grooved switch rail A which is 8 or 9ft. long, raises the outer wheels 1-1/2 ins. above the main rail, its heel bringing them upon the raised lead rail of the turnout. At the same time, the elevating rail B on the outside of the main track, engages the outside of the treads of the inner wheels and raises them in

the same way. If trailed through from the siding when set for the main track the wheels run upon grooved castings C and D the latter of which guides the inner wheels over the main rail, when the flanges drop into place. If trailed through on the main track when set for the siding, the wheels open the switch by forcing back the pivoted guard rail E. A modified form is now made in which all points are made of the ordinary rails, the grooved rails being dispensed with. Owing to the sharp elevation of the switch rails this device is not adapted for high speed tracks. Also owing to its bulkiness and its cost this switch has never come into what may be termed general use. For shunting or flying in cars rapidly it is not satisfactory and in fact derailments have happened to trains coming out of the switch at speeds which would have been safe over a point or stub switch. As the switch has no contact with the main line when not in use it is subject to but very little wear, and the main track rails are free to expand in either direction without fouling the switch rails or shoving the switch rods against the ties.

Another switch built on the same plan as the one just described is known as the Mac Pherson Switch. The inner switch rail laps over the main rail when this switch is set for the siding the switch rails, which are slightly higher than the main rails, engage with the wheel treads. The wheels are thus raised sufficiently for their flanges to clear the main rails.

The Elliot lap switch is in general an improved stub switch in the fact that the ends of the moving and stub rails are beveled so as to lap a few inches by each other on the head-

shoe. For strength, the ends of the stub rails are flared and the web is retained in the beveled portion, the bevel being formed by planing off one side of the head and base. The ends of the fixed rails are bolted together through fishing blocks which restrict the creeping of the moving rails to a safe limit. The switch was designed to overcome one of the objections raised to the stub switch due to the running of the rails from expansion, contraction or creeping of the steel. The long switch provides a continuous bearing rail regardless of a moderate amount of creeping and leaves a good deal of room at tapping head-blocks.

These different devices have all been brought out on account of the accidents due to the breaking of points or becoming jammed in some manner caused by throwing the switch, snow or loose bolt. One of the weak points of switch points, namely the breaking of the point, has been remedied almost entirely. This is accomplished in two ways; First, by riveting or bolting a piece of bar iron on one or both sides of the points which not only reinforces the point but in case the point should break holds the rail in position until replaced by a new one. The second way to accomplish the same use as well as to increase the life and durability of the points is to make the points partly or entirely out of hardened steel. These hardened steel points have in some cases even been further strengthened by bolting on one or both sides of the point a piece of bar iron. The advantage of using these hardened steel points is that the life of the points is increased in a very much greater proportion than the increase in cost. The companies who handle these har-

dened steel points have added greatly to the value and ultimate economy in the use of these points by being able to restore worn points by means of a patented process. Sketch XXXVII shows a design of hardened steel points.

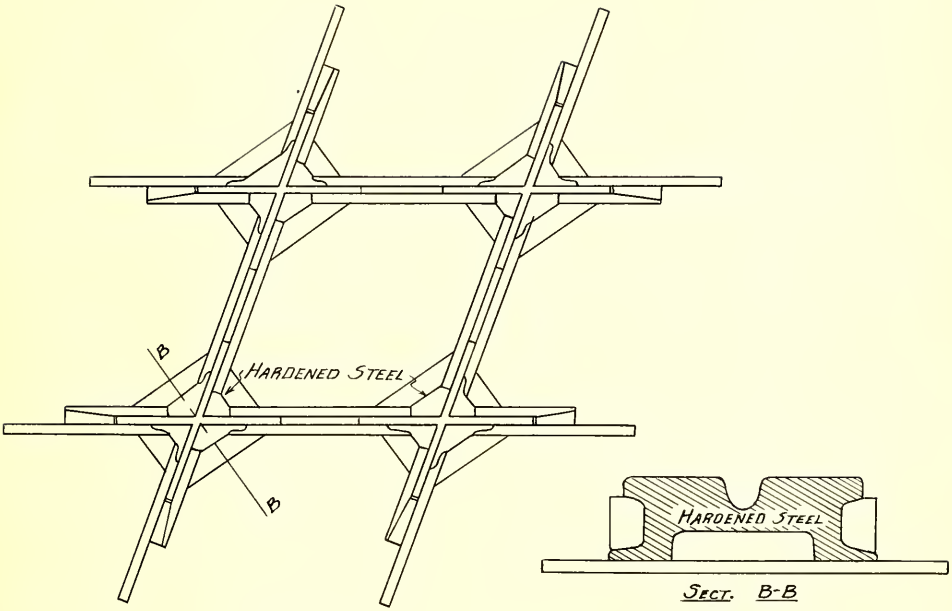
Sketch XXXVII.

[illegible]

[illegible] cross or the second road [illegible] to [illegible] to [illegible] the road [illegible] road. [illegible] of the first road to [illegible]. Practically the [illegible] construction is [illegible] the jump crossing.

The [illegible] was well developed [illegible] days so [illegible] process was known. [illegible] used light sections of rail [illegible] this made it [illegible] to weld two or more pieces [illegible]. [illegible] use of [illegible] to construct crossings. [illegible] were cut a [illegible] length [illegible] set to the [illegible] space, then the abutting rails were cut to the [illegible] angle and placed in [illegible] cut. They were [illegible] clamped together and welded. [illegible] by the use of [illegible] weights of rail, which became necessary through heavier rolling stock [illegible] speed of trains.

Sketch XXXVIII.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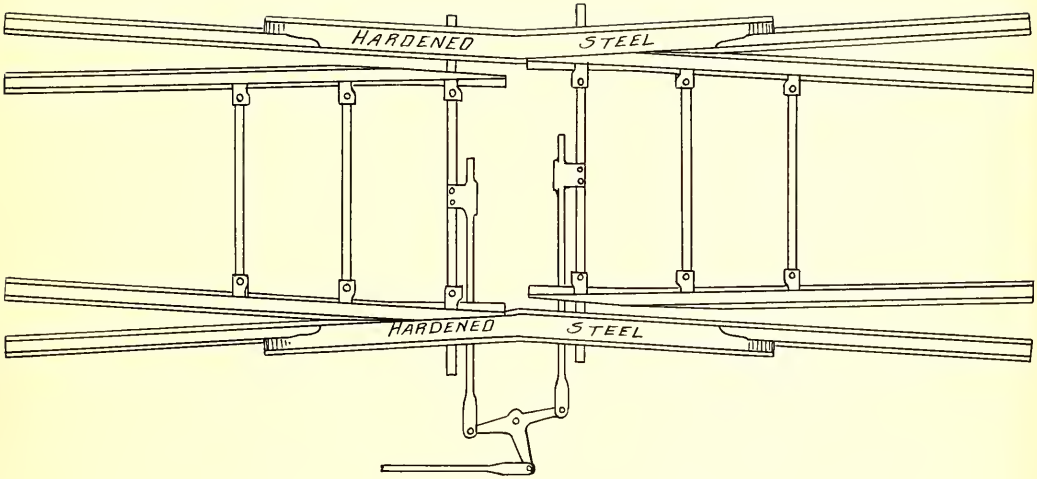
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